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Assessment of Rain Water Harvesting Facilities in Esanland of Edo State, Nigeria

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ABSTRACT This paper examines the structural and environmental aspects of the use of underground wells in Esanland of Edo State. The structural aspects dealt with the structural condition of the wells which was observed to be poor because many wells had cracks and leakages, surface peelings, bad channels and coverings. The environmental aspects described the conditions of dust, smoke, household effluents, waste dumps, bushy surroundings, flooding and erosion affecting the wells. Due to these conditions, it was observed that water needs from the wells were not met adequately in the study area. To be able to meet with the demand, other sources of supply were sort and this affected the finances of the people. Data used for the study were obtained from primary and secondary sources. Analysis was simply descriptive statistics using tables.

INTRODUCTION

Lack of public water system in the rural areas and the inability of water facilities to function effectively in the towns and cities of Nigeria have made it impossible for most of her population to have access to portable water. According to Orebiyi et al. (2010), 52 percent of Nigerians have no access to improved drinking water supply. Sources such as rivers, boreholes, streams, wells, ponds and rain are still very much depended upon for water needs. The health implications of the use of these sources include alarming rates of water - related diseases and deaths among the population. In World Health Organization's (2000) estimates, 4 billion cases of diarrhea are reported each year around the world, in addition to millions of other cases of illness associated with lack of access to clean water. Gleick (2002) estimated global deaths arising from water- related diseases at between 2 - 5 million yearly. Although there are no accurate data on water related cases and deaths in Nigeria, studies have however shown that cases of typhoid, cholera and other water related disease and deaths have been on the increase in recent times.

According to the WHO (2003), 200,000 people in Nigeria were estimated to be blinded of trachoma with overall prevalence blindness of 1.3 percent. Studies on schistosomiasis infection in different parts of Nigeria by Nmorsi et al. (2005) and Pukuma et al. (2007) show that infection rate is high. They attributed this to the use of infested rivers, streams and ponds for drinking and for other domestic purposes by a large population of country. Earthwatch (2008) estimated diarrhea prevalence rate in Nigeria at 18.8 percent and is the second largest killer of Nigerian children. The study of Ojeifo et al. (2009) on the prevalence and distribution of water related diseases in Owan east local government of Edo State, Nigeria, show that there are increasing cases of typhoid, diarrhea, schistosomiasis and trachoma among the population. The study showed that between 2002 and 2005, 5.8 percent of the population was affected by typhoid while 2.8 percent had diarrhea. Lack of access to pipe borne water in the local government area and the reliance of the population on streams, rivers and ponds for water use was mainly responsible. The assessment of water quality and prevalence of water borne diseases in Amassona in the Niger Delta of Nigeria by Nwidu et al. (2008) showed that the number of patients reported and diagnosed with water related diseases was increasing. He noted that while only 14.61 percent were reported and diagnosed in 2005, 34.83 percent and 50.56 percent were reported and diagnosed in 2006 and 2007 respectively, showing a progressive increase. They said that those diseases that were consistently reported and diagnosed for the period of study were cholera, diarrhea, dysentery and typhoid. The study attributed the prevalence of these diseases to the contamination of the river in the community.

Most of the population of Esanland use water from different sources. The most depend-able source however is the underground storage tank which is referred to as 'artificial' or 'dug-out' well in the study area. These are found in every house and over 95 percent of the people depend on them for water supply during rainy season while about 78 percent depend on them during the dry season (Okhae 2005). As important as the wells are in the area, it is sad to note that structural and environmental factors are affecting the wells and their use. This has worsened the water supply situation in the area, with many becoming inaccessible to portable water from their wells. This study is meant to examine the structural and environmental factors affecting wells and their impacts in the study area.

Theoritical Background

Studies on well and well water have variously been carried out, using different methods. Few of these studies and their methods are discussed in this study. The need for this is to identify the suitability of the method used in this study.

In the study of the relationship between water chemistry and depth of hand dug wells in a densely populated part of Ibadan, Nigeria, Ifabiyi (2008) used multivariate procedure of multiple and stepwise regression analysis to analyze his data. Result of the multiple regression and correlation showed that coliform count, pH, total hardness (TH), calcium (Ca), magnesium (Mg^{+}), Iron (Fe) and Cloride (Cl) increase with increasing depth while nitrates (NO_3) and bicarbonate (CO_3) reduce with depth.

Adesiyun et al. (1982) did a study on well water and possible health risks in Katsina. To achieve the study, he took samples of well water for analysis from all four wards in Katsina town. In all 20 samples of water were used. Laboratory analysis showed that all, 20 samples taken had high coliform counts. In all, 65 percent of wells contained ≥2400 coliforms per 100ml while the remainder had counts ranging from 79 to 920. Faecal coliforms and non-cholera vibrios were detected in all samples. For the coliform count, 100ml of freshly drawn well water was put in a sterile 200ml bottle and ice-cooled until used. Approximately 5.0ml of well water was added to 10.0ml of selenite Fbroth for salmonella-shigella detection while for vibrio detection, 10.0ml of alkaline peptone water (APW) was used as a transport medium. Apart from laboratory analysis, questionnaire were also used to obtain information on the number of persons in the household, number of persons in the household with recent gastroenteritis and the condition of the well in the household and the relationship with latrine. Data from the questionnaire enabled the researchers to determine the common ailments associated with the wells and the number of persons that were suffering from such ailments.

In the study of quality of well water in Ede area, south-westen Nigeria, Adediji et al. (2005) selected a total of 21 hand dug wells. The environmental conditions around the well which are likely to affect water quality composition were noted. In the study, the chemical quality of the water from the well was investigated. The selected chemical properties examined were pH, electrolytic conductivity (TDS) and cations concentration such as calcium (Ca^{2+}) magnesium (Mg^{2+}) sodium (Na^{+}) and potassium (K^{+}). The results of the study showed that potassium (K) was the most abundant dissolve cations in the well water sampled in the area. All the dissolve cations such as $Ca2^{+}$, $Mg2^{+}$, Na^{+}, and K^{+} are generally conformed with the recommendation of WHO maximum limits. However, since most of the inhabitants of the area depend on well water supply for drinking, the researchers recommended that waste disposal facilities should be sited in the outskirt of the towns. In this regard, the site of the well should be at least 30m away from any source of contamination.

In evaluating the various methods discussed, it has shown that questionnaires could be used to determine the impact of well water on the health of households. Also environmental factors affecting the wells such as waste disposal, location of septic tanks and latrines, sewage facilities, rainfall, dust particles, erosion and flooding could also be used as determining factors in assessing well and quality of well water. Most important is the use of laboratory test on the chemical properties of well water to ascertain its quality. In this study, a combination of questionnaire, environmental factors and chemical analysis were used to determine the aspects of the quality of well water in Esanland.

METHODOLOGY

Data used in this study were collected from two sources: primary and secondary sources. The primary sources include questionnaire and personal observation. For the questionnaire, 150 were made and distributed in 5 selected towns in Esanland. The towns were Ekpoma, Irrua, Igueben, Uromi and Ubiaja. 30 questionnaires were distributed in each of these towns. In each town, 6 streets were randomly selected, and 5 questionnaires were distributed in each street and administered in one household in 5 selected houses with wells in the street. Among the data collected with the questionnaire are, age, depth, use and the frequency of the cleaning of wells. Apart from the use of questionnaires, personal observation was also vital for data collection in this study. With it information regarding the nature of the environment and the material used in constructing a well were ascertained. To determine the quality of water, analysis of the chemical and microbiological aspects of the well water was carried out in the Edo State water corporation laboratory in Benin City.

Secondary data used in this study were derived from published and unpublished materials such as textbooks, articles in journals and unpublished thesis. The data include the 2006 population census figures and the physical size of the study area. Others include methods of waste disposal, average chemical and microbiological constituents of well water standards and standards regarding distance of well from septic tanks, latrines. The data collected from all the sources were analyzed descriptively and statistically. The statistical analysis involves the use of simple percentages.

STUDY AREA

The study area is Esanland. This comprises the 5 local government areas of Esan west, Esan central, Esan north-east, Esan south-west and Igueben in Edo State, Nigeria. For this study, Esanland is restricted to the headquarters of these local government areas and they are Ekpoma, Irrua, Uromi, Ubiaja and Igueben respectively. This area is located between latitude $6^{0}10'$ and $6^{0}45'$ north of the equator and between longitudes $6^{0}10'$ and $6^{0}30'$ east of the Greenwich Meridian. The latitudinal location implies that the study area falls within the tropical region. The tropical climate is dominated by high temperature, high humidity and heavy rainfall. The area is characterized by two distinct seasons, the wet season which lasts between March and November and the dry season which lasts between November and February of each year.

This area is situated on a relatively flat plateau called the Esan plateau and it is approximately 466m above the sea level (Akinbode 1983). Apart from the very few areas where there are remarkable valleys with exposed surface drainage, the study area is almost devoid of surface water sources. The water aquifer of the study area is very low and is put at approximately 150m. This depth has also made it almost impossible to have access to underground water source in the area.

The 2006 national census put the population of the study area at 591,534 people. Projected to 2009 at 2.8 percent national growth rate, the 2009 population of the study area is 642,623. This area has a land area of $2{,}729.93km^2$. Secondary and tertiary activities such as commerce, hotel services, teaching, banking and health services are highly engaged in the area but the dominant occupation of the people is agriculture. This has been favored over time by the rich and well-drained sandy loam which retains the advantage of good food and cash crop cultivation (Akinbode 1983). The vegetation is the mixed type of forest and Savannah, popularly called derived vegetation.

There are several social facilities in the area; these include electricity, hospitals, schools, markets and roads. The major facility lacking in the area is water. Apart from Ubiaja and its surrounding rural neighbours, no other single town or village in the area is provided with pipe-borne water. The inability to provide water has been attributed to the absence of remarkable surface water sources such as rivers and lakes and the low water table of the plateau, which has been difficult to access due to lack of technology. Majority of the people of the area therefore rely on other sources for water supply, prominent among which is the use of underground storage tanks popularly called 'wells' in this area. Rainwater is collected into these wells during the rainy season while water may be bought into it during the dry season to become the source of supply.

RESULTS AND DISCUSSION

The Nature of Underground Storage Tanks (Wells) in the Study Area

Underground storage tanks, also call wells in the study area, are very popular. They are found in almost every house in the area. Their ubiquitous nature is due to the fact that it is the most reliable means and source of water supply for families and households in the study area. The wells are usually constructed around the house. The construction starts with digging, usually with manual labour, of a choice place around the house' to a pre-determine size. Field study shows that sizes of wells vary between 7ft to 12ft in width and between 12ft to 25ft in depth. The width and depth of a well depends, among others, on the space available, financial affordability of the owner of the house and the nature of the land. From the survey, it was established that most of the wells have a depth of between 18-20ft as this accounted for 47.3 percent of the wells. Those from 23ft and above were 3 and accounted for only 2 percent of the wells. Table 1 shows the number and percentage variation of the depth of sampled wells in the study area.

Table 1: Depth of sampled wells in the study area

Towns	*(16-17ft)*	*(18-19ft)*	*(20-23ft)*	*(23ft and above)*	*Total*
Ekpoma	6	16	8	-	30
Irrua	10	13	6	1	30
Uromi	11	9	10	-	30
Ubiaja	6	14	10	-	30
Igueben	5	19	4	2	30
Total	38	71	38	3	150
Percentage	25.3	47.3	25.3	2	100

Source: Field survey 2007

After digging, the well is plastered, first with clay-mud and cement and later with sand and cement. The mixture of clay-mud and cement produces a starchy material, which is believed to cleave very strongly to the walls of the well. It is therefore use in the first layer plastering of the walls of the well. It is believed also that this mixture is tough enough to prevent any leakage, particularly in the first few years of construction. After this first layer, subsequent layers are done with sharp white sand and cement. Between two to three layers of plastering is often used for the wall of wells. The addition of other layers is to make the walls thick enough to prevent water leakage and the collapse of the walls.

The base of the walls of the well is usually plastered with a mixture of granite and cement and[it] is made thick enough to be able to hold the weight of the plastered layers of the walls, and, more importantly, to prevent water leakage at the base. Tops of wells are covered differently. There are those covered with wood and roofing sheets, which are built conically around the well. There is the other type made of concrete, which is usually constructed flat and circular over the top of the wells. The shapes of most wells are circular while few others are square. Of the sampled wells, 129 or 86 percent are circular while 21 or 14 percent are square.

For wells to have water, channels are usually constructed along the base line of roofing sheets on housetops and connected into the wells. This channel receives the rainwater on the roofing sheets and allows it to flow easily into the wells. The channels are often made of different materials including aluminum, zinc and plastic pipes. As long as the rain lasts, water keeps collecting in the wells for domestic and other uses. For those that can afford it, empty wells are usually refilled with water bought by tankers and other water vendors during the dry season.

The make of rooftops or roofing materials of the houses from which water is collected into the wells was investigated. The result showed that the rooftops are of three types. They are the common zinc, asbestos and aluminum. The survey further revealed that 113 or 75.3 percent of the houses have zinc as their roofing material. Houses with asbestos were 16 or 10.7 percent while those roofed with aluminum were 21 or 14 percent. The condition of these roofing materials and their effects were not taken into account in this study since the focus is on determining the structural and environmental condition of wells and establishing the quality of water in the wells based on these conditions.

Wells are usually dug around the house. The space available, direction in which water will flow and the ease of the use of the wells were identified as factors that often determine the choice of placement of wells around the house. In this study, wells were found both in the front, sides and back of houses. While 68 percent of the wells were placed in front of houses, 23 percent and 9 percent were dug at the back and side of houses respectively.

Structural Condition of Wells in the Study Area

Two factors affecting the well and its use were studied in this research. They are the structural and the environmental factors. The study on the structural factor revealed the structural conditions of the wells. Three criteria of good, fair and poor were used to determine the condition of wells in the study area. The good wells are those that are structurally strong both on the inside and outside with no evidence of cracks or leakage or damaged cover and channel. As shown in Table 2, they account for 32 percent of the wells under study. The wells with fair condition are those that show evidence of weakness in their structures. Such weaknesses include cracks and surface peelings; weak water channels but with no evidence of leakage. This category accounted for 46.6 percent of the wells under study. The wells with the poor condition include those with severe cracks and leakages, surface peelings, bad channels and coverings. The wells in this group accounted for 21.3 percent. By this analysis it therefore means that the condition of most wells in the area is fair.

Table 2: Structural condition of wells in the study area

Location	*No. of wells*	*Condition of wells*		
		Good	*Fair*	*Poor*
Ekpoma	30	9	14	7
Irrua	30	11	16	3
Uromi	30	11	14	5
Ubiaja	30	8	12	10
Igueben	30	9	14	7
Total	150	48	70	32
Percentage	100	32	46.6	21.3

Source: Field survey 2007

If the 46.6 percent that are fair are however combined with the 21.3 percent that are in poor condition, it means that the structure of most wells in the study area are not very good presently. Three factors were identified to be responsible for this; they are age of wells, lack of maintenance, poor materials for their construction and poor construction. On the basis of age it was observed that only 18 percent are recent and were constructed between 0-5 years, 27 percent were constructed between 6-10 years, 22 percent were constructed between 10-15 years ago while 33 percent were constructed 15 years and over. It was observed also that most of the wells that are of poor conditions were those constructed over 15 years ago. On the basis of the type and depth of materials used, it was observed that 36 percent of the wells had their inside plastered thrice while 64 percent had their inside plastered twice with cement. Also, 41 percent have concrete covering while 59 percent have zinc with wooden frame covering. Wells with zinc/wood frame covers were observed to depreciate easily. This is because the zinc rusts while the wood frame rots easily. As observed in some of the wells with such coverings, the portions of rust zinc and the rot frames were seen to have fallen into, and floating on the water. Wells with very badly torn and damaged zinc coverings also permitted dusts and other atmospheric contaminants into the water.

Environmental Condition of Wells

The environmental condition of wells was discussed within the context of the factors affecting the housing environment. The housing environment is simply the environment of a place of residence. In the study area, the residential environment is characterized by the discharge of household effluents, indiscriminate waste dumps, dust and smoke, bushy surroundings, flooding and erosion. It is in this environment that wells are dug and used in the study area. An examination of these prevailing conditions shows that they affected wells in the study area. The number of sampled wells affected by each of these conditions is shown in Table 3.

Table 3: Number and percentages of sampled wells affected by environmental conditions

Type of Condition	*No. of wells*	*%*
No. of wells not affected by any condition	15	10.0
No. of wells located close to waste dumps	73	48.7
No. of wells located close to latrines and septic tanks	19	12.6
No. of wells threatened by erosion and flood	43	28.7
Total	150	100.0

Source: Field survey 2007

As shown in Table 3, wells located close to waste dumps are more prominent in the area as indicated by 73 or 48.6 percent of the sampled wells. Also, those located close to latrines and septic tanks were 19 or 12.6 percent while those threatened by erosion and flood were 43 or 28.7 percent. Only 15 or 10 percent of the wells were not affected by these conditions.

Table 4: Distance between wells and waste dumps

Location	*No. of wells located near waste dumps*	*Distance between wells and nearest dumps (in metres)*			
		0-10m	*11 – 20m*	*21– 30m*	*31m - Above*
Ekpoma	21	3	12	4	2
Irrua	11	6	4	-	1
Uromi	16	2	8	2	4
Ubiaja	10	1	4	5	-
Igueben	15	3	6	2	4
Total	73	15	34	13	11
Percent	100	20.5	46.5	17.8	15.1

Source: Field survey 2007

Indiscriminate waste dump is very pronounced in the residential environment of the study area. According to Ojeifo (2005), waste dumps in form of food remnants, bottles, papers, metals and plastic materials are common sights of the house environment in urban centres. In the study area, these wastes are often seen in heaps in the frontages, sides, back and available open spaces around most houses. Most alarming is the fact that some of these dumps are usually put by the wells. A measure of the distance between wells and nearest waste dumps is shown in Table 4.

As shown in Table 3, a total of 73 or 48.7 percent of wells out of the 150 under study have waste dumps around them. 20.5 percent of these wells have waste dumps as close as between 0-10m while 46.5 percent are as close as between 11-20m. 17.8 percent and 15.1 percent of the wells have wastes dumps as close as between 21-30m and 31m and above respectively. A close analysis shows that 67.1 percent of the wells with close waste dumps have dumps as close as between 0-20m, while 32.9 percent have dumps at a distance of 21m and above. Waste material containing soluble products are capable of infiltrating the land to cause groundwater pollution (Eseigbe et al. 2007). According to Hughs (2004), waste at the stage of decomposition emit chemical substances that are easily infiltrated into the ground during rainfall. In this process, underground water sources, including wells, get contaminated easily. Apart from waste dumps, it was also observed that 19 or 12.6 percent of wells under study were ignorantly dug very close to latrines and septic tanks as shown in Table 5. These wells were found to be as close as between 3-6 metres, as against the US Environmental Protection Agency's recommended minimum distance of 50ft or 15.24m (Wellcare 2010). The gradual seepage of septic waste is capable of contaminating underground water sources including wells. In a recent study of the sources of groundwater resource contamination in Benin City, Eseigbe et al. (2007) identified effluents from septic tanks and privies as contributor to ground water pollution in Benin City.

Table 5: Distribution of wells located close to latrines and septic tanks

Location	*No. of wells*	*%*
Ekpoma	4	21.0
Irrua	6	31.6
Uromi	3	15.8
Ubiaja	2	10.6
Igueben	4	21.0
Total	19	100.0

Source: Field survey 2007

As shown in Table 5, of the 19 wells located close to septic tanks, Irrua had the highest number of wells as accounted for by 31.6 percent of the wells while Ubiaja had the least number of wells with 10.6% of the wells.

Due to lack of drainage in most parts of the study area, many houses usually suffer from erosion and flooding during rainfall. Erosion and flood, which often flow as contaminated water, sometimes find their way into wells that have cracks, passages and other structural defects. Such flows often contaminate the water in the well. A survey of this shows that 43 or 28.7 percent of the wells are been affected by erosion and flood waters.

As shown in Table 6, of the 43 wells affected by erosion and flood waters, Ekpoma had the highest number of wells as accounted for by 31.2 percent of the wells while Igueben and Irrua had the least number of wells with 11.6 percent of the wells each.

Table 6: Distribution of wells affected by erosion and flood waters

Location	*No. of wells*	*%*
Ekpoma	13	30.2
Irrua	5	11.6
Uromi	11	25.7
Ubiaja	9	20.9
Igueben	5	11.6
Total	43	100.0

Source: Field survey 2007

The action of local winds, moving vehicles, people, and other human activities constantly keeps the air polluted, especially with dust and smoke. This dust and smoke often find settlement in any available space. One of such space is rooftop. The amount of smoke and dust concentrate on rooftops cannot be quantified, but the extent can be determined. The level of concentration varies with seasons. In the rainy season, wet soil particles do not rise easily, which makes the level of concentration of dust very minimal. But during the period of drought in the wet season and during the dry season, soil particles are easily lifted and therefore increase dust concentration on rooftops. The fact that wells are connected to rooftops means that a great amount of dust is also collected with the rainwater. It must be emphasized that apart from the dust itself, other microelements which settle in the dust, flow with water into the wells and make it unclean.

Effects of These Conditions on the Quality and Use of Well Water in the Study Area

On the basis of the prevailing structural and environmental conditions of the wells, it became necessary to examine the quality of well water consumed from these wells. To do this, the physical, chemical and microbiological constituents of the water were identified and analyzed. For the physical constituents, presence of colour, particles and odour in water were used as determinant factors. Table 7 shows the number of wells with these characteristics.

As shown Table 7, 10 percnet of the well water have colour, 2 percent have odour, and 19.3 percent have particles while 68.6 percent are clean. As observed in the study, the coloration of the water and the presence of odour were due to long sedimentation of dust and other decaying materials. Presence of particles was due to the fall on the water of decaying wood and other materials such as zinc that was used as cover for the wells.

Table 7: Number of well water with colour, odour and particles

Location	*No. of wells*	*Colour*	*Odour*	*Particles*	*Clean*
Ekpoma	30	3	-	8	19
Irrua	30	7	2	9	12
Uromi	30	3	1	9	17
Ubiaja	30	-	-	5	25
Igueben	30	2	-	13	15
Total	150	15	3	34	98
Percent	100	10	2	19.3	68.6

Source: Field survey 2007

The presence of particles, odour, colour and sediments in 52 or 34.6 percent of the wells, suggest that these wells are not washed regularly. Investigation on how often wells were washed or cleaned by households in the study area shows that not many households wash their wells very often as shown in Table 8.

Table 8: Frequency of well cleaning

No. of cleaning per year	*No. of wells*	*%*
Once every year	28	18.7
Once in 2 years	57	38.0
Once in every 3 years	38	25.3
Once in every 4 years	16	10.7
Once in every 5 years	6	4.0
Not washed in the last 5 years	5	3.3
Total	150	100.0

Source: Field Survey 2007

As shown in Table 8, 18.7 percent of the wells were cleaned once every year, while 38 percent were cleaned once in every 2 years. Also, 25.3 percent were cleaned once in every 3 years while 10.7 percent and 4 percent of the wells were cleaned once in every 4 and 5 years respectively. Also, 3.3 percent of the wells have not been washed or cleaned in the last 5 years. Therefore, if the number of cleaning years of wells were put together, it can be seen that 74 percent of the wells were cleaned once in every 2-4 years. This is an indication that most wells are usually full of sediments and particles before they are washed.

For the chemical and microbiological constituent of the water, test was conducted on the water from the 68.6 percent clean wells. The use of this physically clean well water for analysis was to ascertain their suitability for consumption, especially drinking. Three wells of the 98 'clean' wells (constituting 68.6% of the sample) were selected from each of the 5 study towns, and a total of 15 wells were thus selected and subjected to chemical and microbiological analysis. For the chemical analysis, water sample from each of these wells were collected in water bottles and stored at low temperature to minimize physico-chemical reactions. The water samples were taken to the laboratory for analysis. The sample parameters used were Calcium (Ca^+), Magnesium (Mg^+) Iron (Fe^+) Chloride (Cl^-), Nitrate (No_3^-), Sulphate (S), Zinc (Zn^+), Copper (Cu^-) and pH. Standard laboratory procedure was used in the analysis as cat ions and anions for these chemicals were determined with atomic absorption spectrometer method using cadmium reduction method. PH was determined with glass electrode pH meter. The result of the analysis is shown in Table 9.

Table 9: Average chemical and microbiological constituents of well water

Chemical parameters (column 1)	*Average chemical and biological constituent (column 2)*	*WHO standard*	
		Acceptable (column 3)	*Maximum permissible limit(column 4)*
Sulphate	2.5	200	400
Nitrate	0.2	50	100
Calcium	1.50	75	200
Magnesium	2.30	50	150
Iron	0.05	0.1	1.0
Copper	0.002	0.05	1.5
Zinc	2.50	5	15
Chloride	14.05	200	600
pH	7.2	7.0-8.5	6.5-9.2
Micro organism			
Coliform (faecal coliforms)	0	-	0

Source: Edo State Urban Water Board, Benin City 2007
Note: All units, except PH and Coliform are in mg/1. Coliform is in most probable number of organism per 100ml.

As shown in column 2 of Table 9, chloride had the highest chemical constituent in the water with 14.05mg/l while copper had the least with 0.002mg/l. When compared with the WHO (1991) acceptable standard, this result is an indication that the well water contains minute quantity of chemicals that cannot be harmful on consumption. The pH test conducted on the sampled well water gave an average pH of 7.2. As contained in column 3 of Table 9, this pH level fall within the neutral range and meets the WHO acceptable standard for drinking water. For biological analysis of the well water, test was conducted for faecal coliforms. The common method for detecting faecal coliforms, Escherichia coli which include filtration, followed by culture of filters on a medium that selectively permits growth of Gram negative bacteria and differentially detects lactose utilizing bacteria was adopted using standard procedure. The result of test shows 0 as in column 2 of Table 9. This means that Escherichia coli were not detected in the sampled well water, which therefore makes it suitable for domestic consumption. The tests and analysis of sampled well water were conducted in the Edo State Urban Water Board laboratory in Benin City.

By way of interpreting the results in Table 9, all well water appears to be of good quality. The result also shows that the quality compares favourably with the World Health Organisation Drinking Water Standard. By this result, it can be said that 68.6 percent of the wells under study are suitable for drinking while 31.3 percent of the wells are unsuitable. This number constitutes those wells that have colour, odour and particles. This is rather a large proportion which indicates that almost half of the households under study do not have access to safe drinking water from their wells.

The suitability for drinking of the 68.6 percent clean well water notwithstanding, many households having these wells do not actually drink from them. The survey shows that 11 out of 98 wells containing clean water were not used for drinking. Reasons by household having these 11 wells are that they are made of cement which is capable of affecting their health. Households who accounted for this reason were 4 or 36.4 percent. Other reasons were that the wells were poorly covered and located too close to dumps and effluents, and 2 or 18.2 percent of households gave this reason. Another reason given by 5 or 45.4 percent households was that the wells were poorly channelled and have structural cracks that allow the easy passage of erosion and flood-water. On the whole, while 87 or 58 percent of the 150 sampled wells

Table 10: Other sources of drinking water by households

S. No.	*Sources of drinking water*	*Ekpoma*	*Irrua*	*Uromi*	*Igueben*	*Ubiaja*	*Total*	*%*
1	Sachet table water	6	3	4	3	4	20	31.7
2	Other wells	5	2	2	4	2	15	23.8
3	Water tankers	8	2	6	2	4	22	34.9
4	Public water system	-	-	-	-	6	6	9.5
Total		19	7	12	9	16	63	99.9

Source: Field survey 2007

are used for drinking and other purposes, 63 or 42 percent of the wells are not used for drinking but for other purposes. By implication therefo-re, 63 or 42 percent of households in the study area use alternative sources of water for drinking. These sources, as identified in this study, are sachet table water (31.7%), other wells (23.8%), water tankers (34.9%) and public tap water (9.5%). All the households that get their drinking water from the public water system are in Ubiaja which is the only town in the study area that has public water system. The distribution by settlements is presented in Table 10.

The financial effects of the use of these other sources of water, especially sachet table water and water tankers cannot be overemphasized. On the financial aspect, it cost a household about ₦140 for an average of 2 bags of sachet table water daily to meet the drinking water needs of the household. Also, those who buy from water tankers (vendors) do so at exorbitant rates. A 1000 litres of water is supplied at the cost of as much as ₦ 800, and can hardly last for more than a week, especially if the uses are combined. Let it be emphasized that water supplied by tankers which is bought for drinking in the area is from the public water system. Water from other sources especially from untreated sources is used for other purposes in the area.

CONCLUSION AND RECOMMENDATIONS

In the absence of piped borne water facilities, the underground wells will continue to be the major source of water for the people of the study area. The structural and environmental problems confronting them have however reduced their optimal use for basic water needs. To therefore secure the wells for all purpose use especially drinking, the following are recommended. First households should improve on the structural condition of their wells. Those wells that were identified to be having cracks and leakages should be reinforced with cement. By this, the life-span of the well will not only be elongated but well water will also be prevented from having contact with contaminants such as erosion, dust and flood water.

Secondly, it is recommended that every well should have concrete covering as against wooden/zinc covering in some wells. This study has shown that particles discharge into water is common in wells with wooden framed/zinc covering. As the wood get rotten with time, it falls in the water thereby making it have wooden particles which bring colouration and odour in well. 18.3 percent of the wells under study have wooden/zinc covering.

To achieve a more hygienic use, it is of necessity that wells are washed regularly. If sediments and particles are constantly removed from the wells it will make them clean enough to be used for drinking and other domestic purposes. It will also reduce the risk of contracting water related diseases. It is, therefore, recommended that wells are washed once every year.

The environment of most wells as shown in the study is deplorable. It is characterized by open dumps, dust, erosion, effluents, flooding among. It is, therefore, recommended that the surroundings of the wells be improved upon. In this regard, waste dumps around wells should be cleared while drainage channels should be provided for to cordon effluents and erosion away from the well area. To further save wells from constant threat of erosion and flood water, all wells covered at ground level should be raised to a minimum of 2ft above the ground. Also, septic tanks very close to wells should be relocated to at least 50ft or 15.24m from such wells as recommended by the US Environmental Protection Agency. This could help prevent seepage of contaminated fluids into wells in the future.

Poor expertise among local builders and the use of inadequate and sub-standard materials in the construction of wells have been identified as one of the reasons for the poor structural conditions of wells. It is of relevance therefore that the services of builders and civil engineers are consulted in the building of wells. Their engagement will enhance the use of quality materials and better construction that will give the well a lasting span.

The people of the study area need to be educated on the best ways to use the wells. The conventional way of drawing water from the well with a bucket tied to a rope is unhealthy and destroys the body of the well easily through constant scratch of the walls as the bucket moves in and out of the well. It is recommended that every house owner connects his or her house with water facilities and provide overhead storage tanks and pumps so that the water can be pumped into the tanks from the well. When this is done, the well will not only be safe from damage, it will also reduce constant pollution of water from dirty buckets and containers used for collecting water from wells or dust and garbage falling into water. It also becomes easier to get water for use from the well as against the stress of drawing water with a bucket.

To reduce sedimentation, channels to well from roof tops should be removed during the dry season and until there is 4-5 times of rainfall after the dry season, the channels should not be engaged. If this is done, the dust concentrate on wells would have been thoroughly washed away to allow the collection of cleaner water in wells during the raining season. Also important is that henceforth, pipe should be used as channels for water collection as they last longer and collect water better than the constructed zinc channels.

This study has shown that structural and environmental conditions of wells affect their use. One of such effect is the lack of use of wells for drinking and for other domestic purposes. This has left many households without access to drinking water from their wells, which has subjected them to heavy financial burden and threat to health. As a way of solving these problems and their effects, recommendations have been proposed and it is believed that a better use of wells can be enhanced in the area if the recommendations are adequately attended to.

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